Inspirations from the past and opportunities for the future

Part 3: Volume measurement, product movements and gas adjustment

This article is the final in a three-part series by AWRI Senior Engineer **Simon Nordestgaard** discussing the history of selected wine industry technologies, current adoption levels and opportunities. It is based on material originally presented at the Australian Wine Industry Technical Conference in July 2019 and published in the proceedings of that conference, reproduced with permission of the AWITC.

Introduction

Prior articles in this series covered the widespread adoption of cross-flow filtration and flotation, the limited adoption of in-tank fermentation progress sensors and the history of continuous fermentation. This final article reviews some winery operations that are currently performed very manually even in large wineries and presents some of the alternative technology options available.

Figure 1. A dip tape used for level measurement.

Volume measurement – is there a better option than a dip tape?

Most Australian wineries currently measure the volume of liquid in tanks using a tape measure with a floating weight on the end (Figure 1). The ullaged distance from the surface of the wine to the top of the tank is measured and the corresponding volume of liquid in the tank is read from a table. This technique is relatively cheap, simple and hygienic. However, it requires somebody to go above the tank to perform the measurement, relies on them performing it accurately and it is not a live measurement. Small differences in level can make quite a big difference in volume measurement (e.g. a 2 cm dip error in a 5 m diameter tank is a 400 L error). Another potential source of error in this (and most of the other techniques discussed below) is any inaccuracies in the tank dip tables, since tanks that are nominally the same often have slightly different volumes.

External tubes next to a graduated scale are another basic level measurement technique that has sometimes been employed by wineries (Figure 2). While these do not require access to the top of the tank, the level would be difficult to view on taller tanks, and it is likely a less hygienic solution than a dip since there is a thin tube containing wine that is at risk of not being properly cleaned.

Hydrostatic pressure at the bottom of tanks has also been used to measure levels in winery tanks. Both mechanical pressure gauges and electronic pressure sensors have been employed (Figure 3). An advantage of electronic sensors is that they can be connected to a Supervisory Control and Data Acquisition (SCADA) system and monitored remotely. Measurement errors increase with height. For example, in the electronic pressure sensor shown, the error in pressure measurement is ±0.2%, so assuming a constant and known liquid density, at 2 m height the error is ±4 mm, while at 10 m it is ±20 mm. A major disadvantage of level and volume

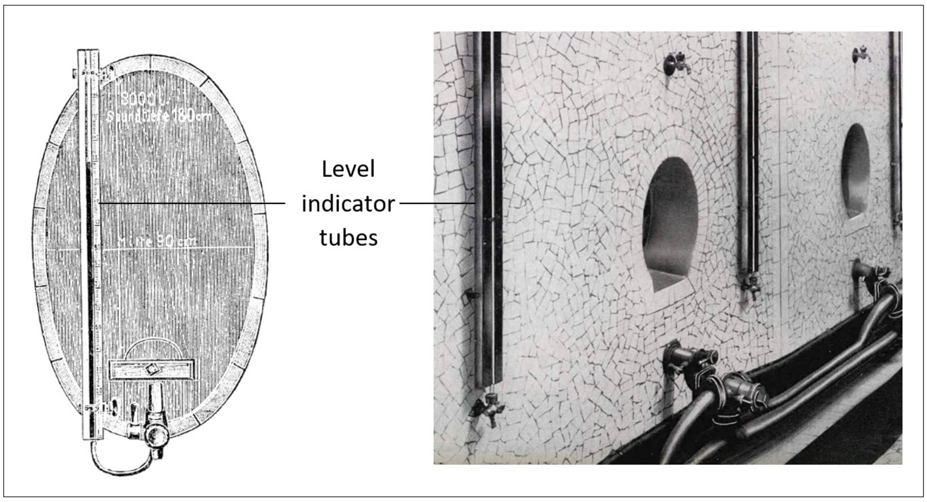

Figure 2. External level indicator tubes (Meißner 1920; Gasquet c. 1950s)

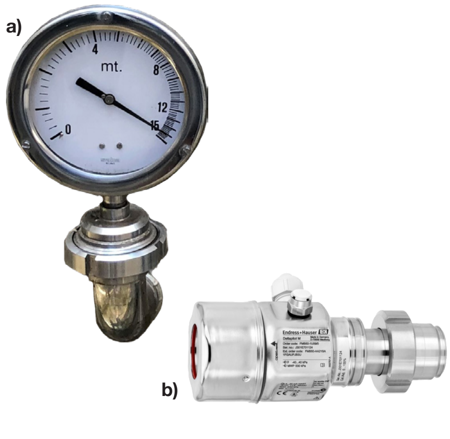

Figure 3. (a) Mechanical pressure gauge (reports in metres based on an assumed liquid density, photo from an Italian winery) and (b) electronic pressure sensor (Endress+Hauser, supplied)

measurement based on hydrostatic pressure is that the results are dependent on density, which can vary with product type and temperature. For example, a density difference of 0.4% between dry red and dry white wine would regularly be encountered (40 mm for a 10 m liquid level) and, more significantly, sweet and fortified wines can often be 7% more dense than dry wines (700 mm for a 10 m liquid level). This issue might necessitate having a second pressure transducer on the same tank so that the real density can be calculated based on the difference in hydrostatic pressure between the transducers (similarly to when using pressure transducers to monitor ferment progress – see prior article in this series).

Radar is another technique for level measurement (Figure 4). This works based on the time of flight of a radar pulse reflected off the surface of the liquid. Radar should generally be more accurate than hydrostatic pressure transducers and the result is not dependent on liquid density. The device shown has an error of ±1 mm across most of its range, increasing up to ±4 mm right next to the sensor. These devices are already used to a small extent in wineries, mainly for sparkling wine pressure tanks where it is not possible to access the inside of the tank to take a manual dip measurement.

Trials have not been performed by the author using these technologies but based on discussions with suppliers it seems likely that they could be very useful. Electronic level sensors will be more expensive than dip measurements

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b)

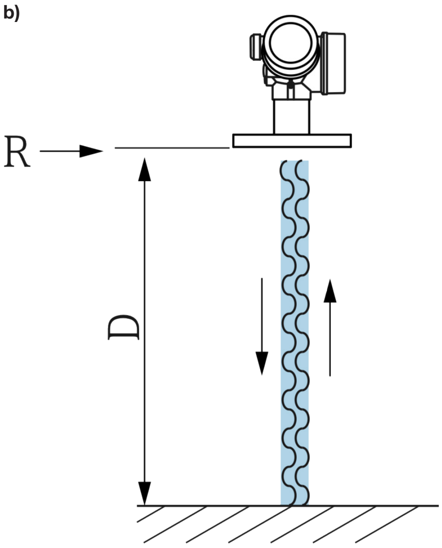

Figure 4. (a) Radar level measurement sensor (80 GHz with a narrow beam) and (b) radar measurement principle (Endress+Hauser, supplied)

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Proceedings of the 17th Australian Wine Industry Technical Conference
awitc.com.au/program/proceedings

AWRI Vineyard & Winery Practices Survey – Final Report
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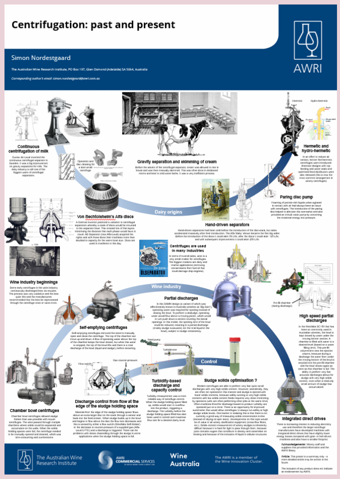

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in the short term. While the cost would be significant, it is likely to be only around 5% of the cost of a 250 kL tank and less for larger tanks and large multi-tank installations (the exact costs would vary depending on the specific circumstances). The installation position would need to be carefully considered to ensure that systems collect the correct

data and do not get in the way of other operations or create cleaning problems.

More sensors would lead to some different skills requirements in wineries; for example, likely more instrumentation maintenance staff and less general labour. At some point, individual sensors will inevitably give incorrect readings and some clever system design is likely to be required to identify and manage these issues. For example, automatic cross-checking between levels measured in feed and product tanks and flow meters in-between during transfers.

The live nature of automated level measurements is likely to provide greater centralised process oversight and can ultimately facilitate greater process automation for product movements. As a basic example, some wineries that installed electronic level sensors many years ago and have them integrated with their SCADA have commented how useful they are for tracking jobs and scheduling which tanks the next batch should go into during the peak of vintage.

Eliminating hoses and automating product movements

Hoses are widely used in wineries because they facilitate the movement of product between any two points. They are a trip hazard, require manual handling and their use is a barrier to improved winery automation (for example they are problematic to 'pig').

Some old winery design catalogues (e.g. Daubron 1931; Gasquet c. 1950s) contain fascinating examples of wineries with very few hoses. These wineries had pipework that went all the way to tanks fitted with multi-way valves (Figure 2) and used centralised distribution boards (e.g. Daubron's 'Centralisateur', Figure 5). One driver in these designs was the need

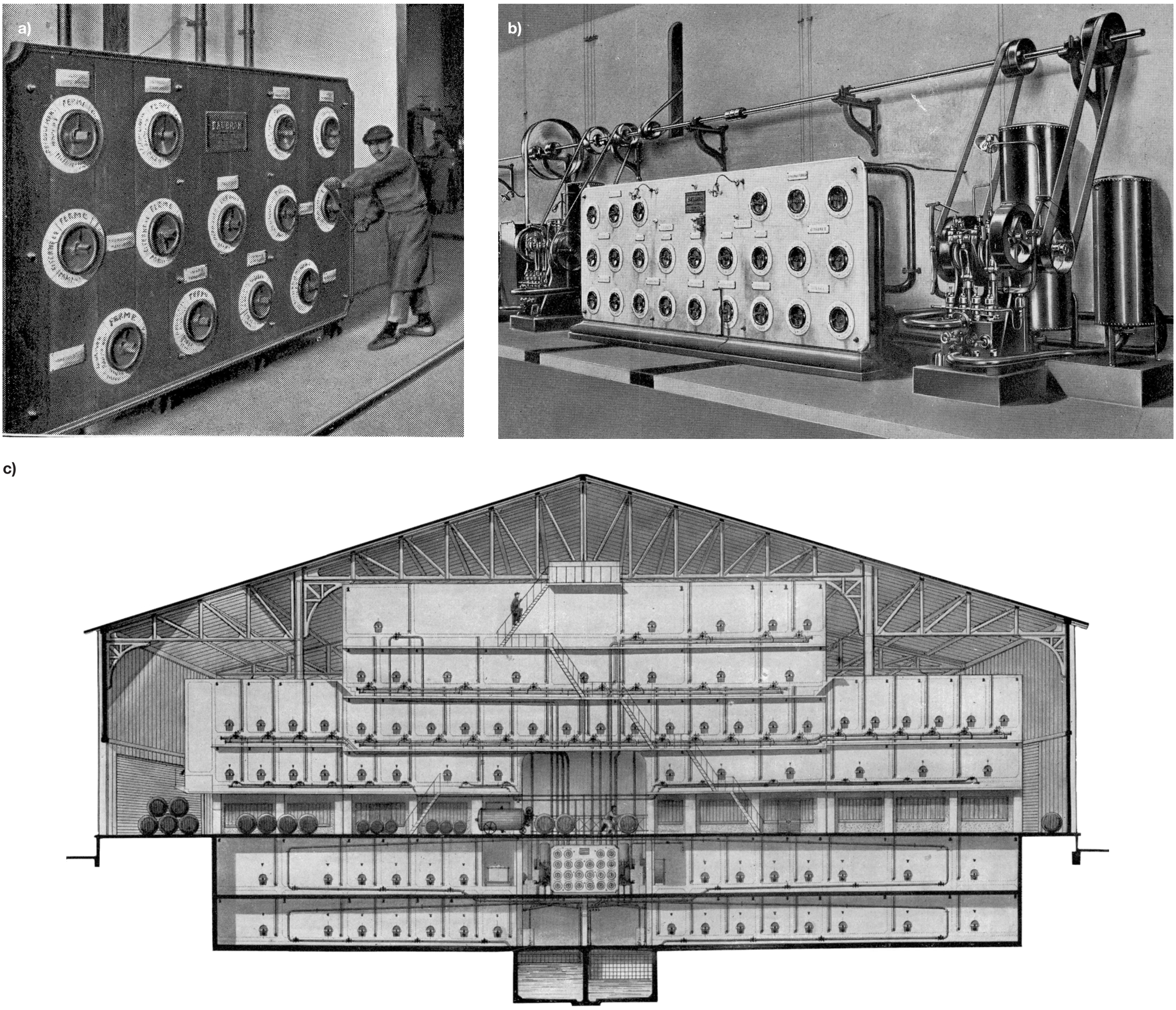

Figure 5. (a,b) Centralisateur distribution boards and (c) a winery built around this principle (adapted from Daubron 1931)

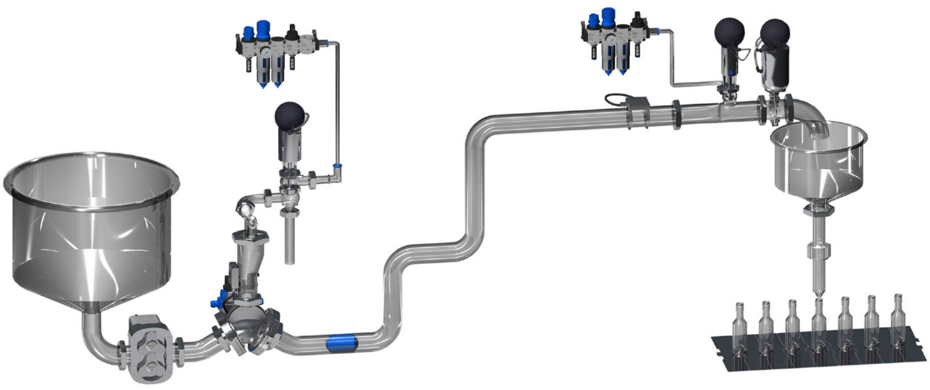

Figure 6. Illustration of a pigging system (Hygienic Pigging Solutions, supplied)

to use fixed steam-powered pumps; they probably fell out of favour following the advent of electrification and mobile electric pumps, and because of issues with hygiene and metal leaching.

However, in some respect these designs are more advanced than many modern wineries despite the much more limited technology available at the time of their construction. They should serve as some inspiration for designers of modern automated wineries. Designers now have at their disposal stainless steel, hygienic pumps and valves, and computers.

Pigging would likely form a part of a modern automated winery. Pigging uses mobile plugs (pigs) to clean, inspect or push products through pipelines (Figure 6). Advanced automated pigging systems are already used at some wineries for key fixed transfer lines, particularly in botting facilities for key transfer lines between the main winery and bottling tanks and between bottling tanks and bottling lines, and on some winery must lines. The use of pigging could potentially be expanded in wineries to all stages of production. Pigging loops around tank farms might be used in addition to the point-to-point systems that are now most common. Increased use of pigging would be expensive but would allow significant process automation and would help with reducing winery water use.

There are other technologies that may also assist with automation, beyond the electronic level sensors discussed and flow meters that are already common in wineries (electromagnetic flow meters are common, but more accurate Coriolis flow meters may be useful in some applications). For example, equipment using electrical impedance spectroscopy to automatically detect interfaces between different liquid types and stop a pump is now commercially available (Figure 7; Cozbel 2015; Pellenc 2019) and cheaper but less sophisticated electrical conductivity and turbidity sensors may also be useful for interface detection in some applications.

a) b)

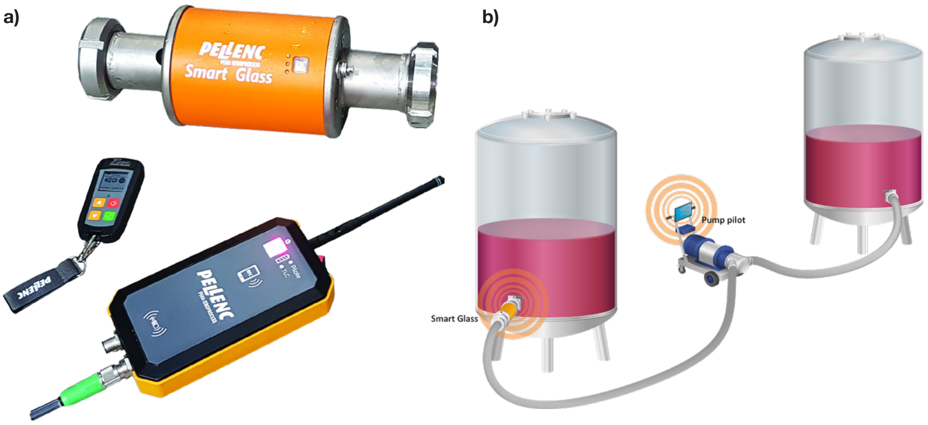

Figure 7. Smart Glass system for interface detection: (a) key components, (b) example implementation (Pera-Pellenc, supplied)

In-line dissolved gas management using membrane contactors

One newer technology that is starting to gain traction in the wine sector is membrane contactors for dissolved gas adjustment (Figure 8). When combined with appropriate control systems these can be used to adjust carbon dioxide levels up or down to a set level, while simultaneously removing some oxygen, all in the same pass. They are a viable alternative to sparging for gas adjustment in the later stages of wine production and potentially allow for looser winery carbon dioxide specifications with adjustments being made automatically during bottling. Membrane contactors can be used for both minor adjustments to carbon dioxide levels and for full carbonation. The 'bubbleless' method of gas addition can also allow for carbonation at warmer temperatures than might currently be practised (Nordestgaard 2018).

Conclusions

This series of articles has outlined a range of technologies that have been used in wineries, including some that have become very successful (such as cross-flow filtration and flotation) and others where adoption has been lower. Something that stands out even in large wineries is that many practices are still very manual. The costs for some of the more automated approaches discussed in these articles may be higher in the short term but they may also be a path to continued improvements in quality and cost reduction in the longer term.

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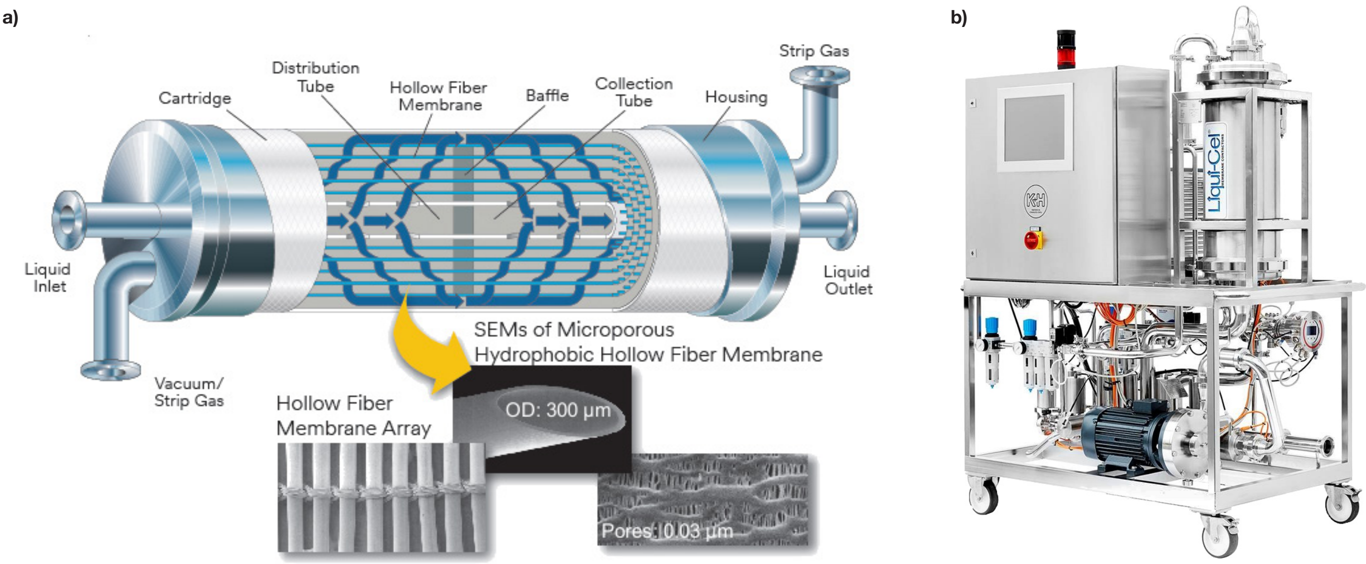

Figure 8. Membrane contactor: (a) module, (b) automated dissolved gas management system incorporating a membrane contactor module (3M and K+H, supplied)

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Disclaimer

Readers should undertake their own specific investigations before purchasing equipment or making major process changes. This article should not be interpreted as an endorsement of any of the products described. Manufacturers should be consulted on correct operational conditions for their equipment.

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